Characterization of Wildfire Producing Storms Utilizing Satellite, Radar, and Lightning Datasets

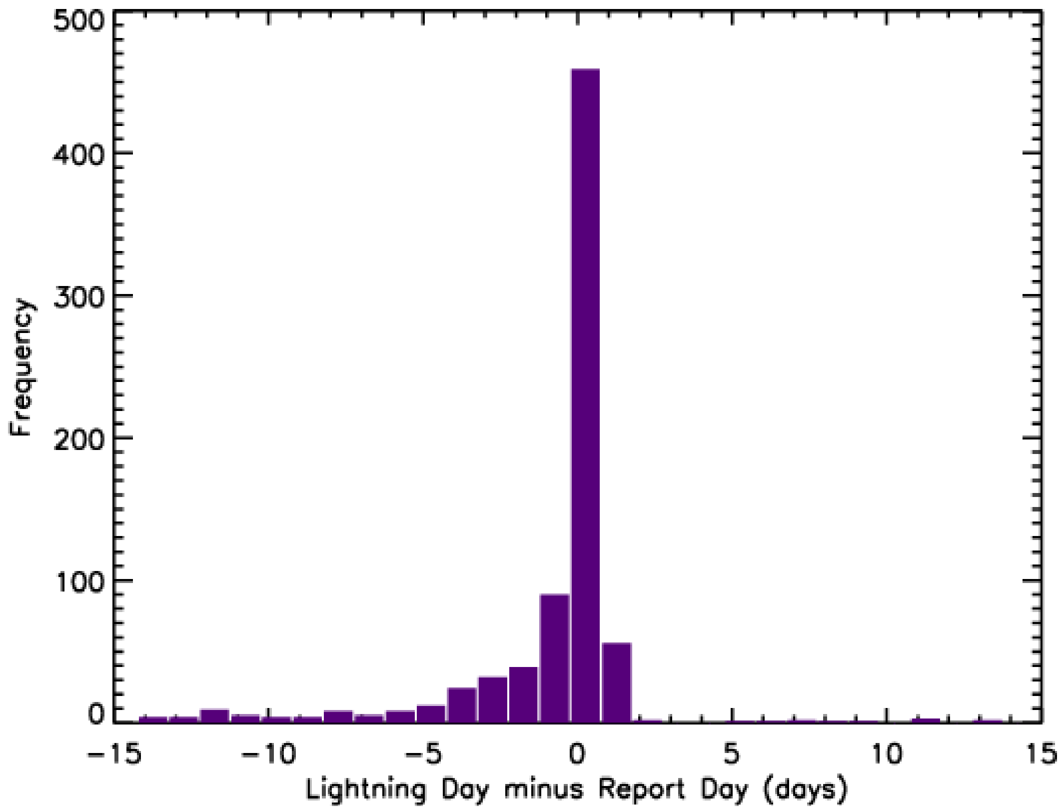
DOUGLAS KAHN AND CHRISTOPHER J. SCHULTZ

1-DEPARTMENT OF ATMOSPHERIC SCIENCE , UNIVERSITY OF ALABAMA HUNTSVILLE/NASA SPORT, HUNTSVILLE, AL

2 – EARTH SCIENCE BRANCH/NASA SPORT, MARSHALL SPACE FLIGHT CENTER, HUNTSVILLE, AL

Introduction and Purpose

- Lightning initiated fires (LIW) make up approximately 16% of the total number of fires within the US, but account for 56% of acreage burned (Balch et al. 2017)
- Billions of dollars are lost each year to fight and prevent these naturally caused fires
- More than half lightning initiated wildfires (52%) are reported on the same day, but a challenge remains to classify the remaining fires (48%) that occur days to weeks before the fire report date (Schultz et al. 2019)



Taken from Schultz et al. 2017

Introduction and Purpose (cont.)

- Oftentimes, these 48% of LIW occur on mountain peaks and low-trafficked areas, making it difficult to quickly detect these events before they become widespread
- Previous studies have studied lightning polarity and the local atmospheric environment, yet many of the flash density metrics used by these methods are rarely attained within the current network framework (Morris 1934, Dowdy and Mills 2012, Rorig and Ferguson 2002, Garcia-Ortega et al. 2011)
- Therefore, there is an opportunity to identify locations of potential LIW starts prior to fire growth using remote sensing and ground-based products

Days from reported fire start	2 km	1 km	0.5 km	0.25 km
-14	0.00%	0.00%	0.00%	0.00%
-13	0.00%	0.00%	0.00%	0.00%
-12	0.22%	0.22%	0.11%	0.11%
-11	0.11%	0.00%	0.00%	0.00%
-10	0.00%	0.00%	0.00%	0.00%
-9	0.00%	0.00%	0.00%	0.00%
-8	0.33%	0.22%	0.22%	0.00%
-7	0.33%	0.11%	0.00%	0.00%
-6	0.33%	0.11%	0.00%	0.00%
-5	0.66%	0.11%	0.00%	0.00%
-4	1.44%	0.99%	0.77%	0.11%
-3	2.21%	1.77%	0.88%	0.33%
-2	2.76%	2.21%	1.10%	0.55%
-1	7.51%	4.97%	3.31%	0.22%
0	43.65%	28.95%	17.02%	6.19%

Previous Studies

Parameter	Overall	Random sample
Magnitude	-CG: reject +CG: accept	-CG: reject (30/30) +CG: accept (26/30)
Multiplicity	-CG: accept +CG: accept	-CG: accept (28/30) +CG: accept (30/30)
0-10 cm soil moisture content	-CG: reject +CG: reject	-CG: reject (30/30) +CG: reject (30/30)
0-10 cm relative soil moisture	-CG: reject +CG: reject	-CG: reject (30/30) +CG: reject (30/30)
GVF	-CG: reject +CG: accept	-CG: accept (18/30) +CG: accept (26/30)
0-200 cm relative soil moisture	-CG: accept +CG: reject	-CG: accept (30/30) +CG: accept (21/30)

- 10 different random samples were computed for the positive and negative polarity non-fire-starting populations for each parameter and then compared to the fire-starting population.
- GVF for –CGs and 0-200 cm relative soil moisture for +CG occurrence from rejecting the null hypothesis of different distributions to accepting that the distributions were the same as the majority of the random samples.

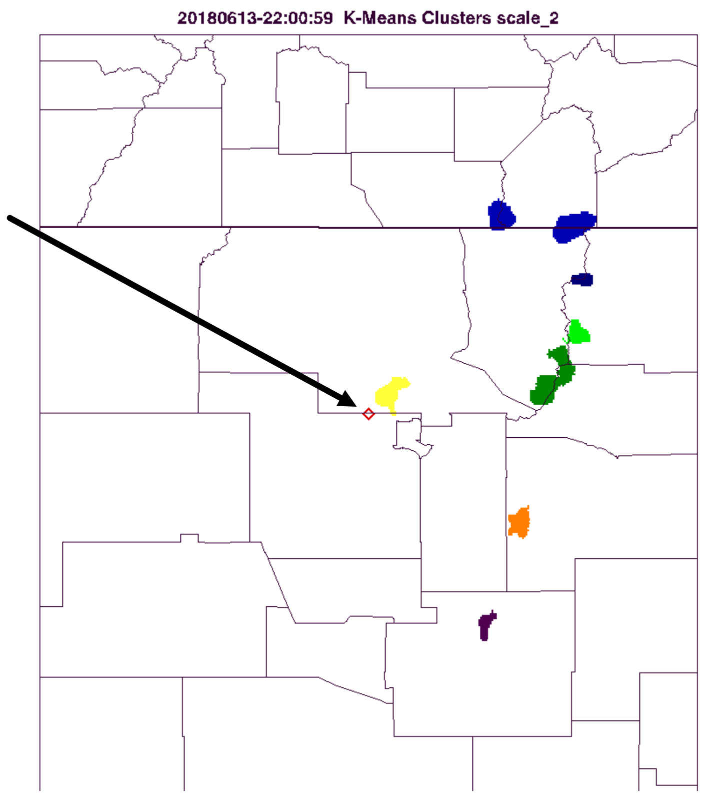
Research Goals and Hypothesis

- What can be determined from these multiple datasets about the structure of both wildfire producing storms and non-wildfire producing storms?
- What type of storms produce the most long continuing current (LCC)?
- Incorporate WSR-88D base and dual pol products, along with model data from the RAP and lightning data from GOES-16 to produce a field named Vilfrd to track individual storms

$$VILFRD = 100 \times \left[\left(\frac{VIL}{45} \leq 1\right) + \left(\sqrt{\frac{FLCT5}{45}} \leq 1\right)\right]$$ - Schultz et al. 2016

HYPOTHESIS

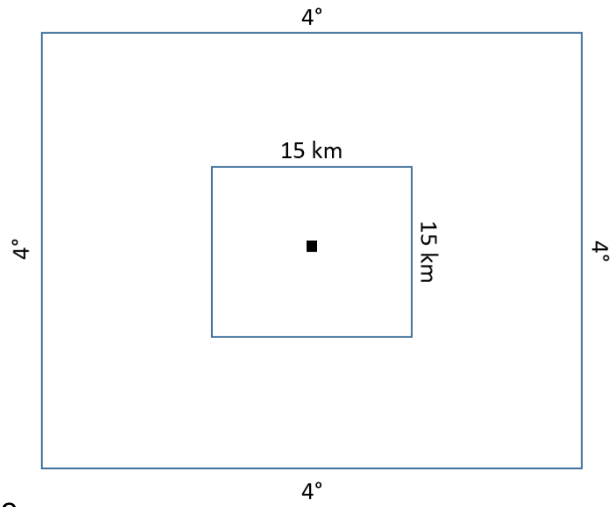
- **A majority of LIW are produced from faster moving storms with lower lightning flash rates and reflectivity values than non-LIW storms**



Tracked storm features, showing scale 2 cluster (blue feature) on June 13, 2018 over reported fire start location (red dot)

Methodology

- Build a database of LIW from 2017 and 2018
  - Incorporate LIW in different environments and regions across CONUS to capture varying storm modes and land surface properties

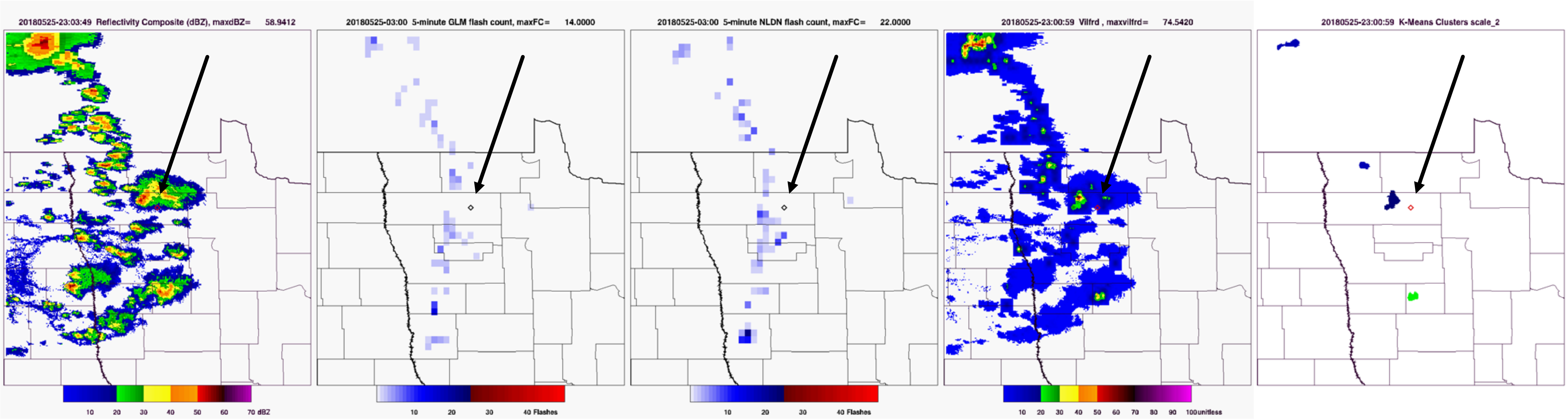


- Use tracking algorithm and separate LIW from non-LIW storms
  - Tracked features within 15 km classified as LIW
  - Tracked features outside 15 km, but within 4° by 4° box from fire point classified as non-LIW to capture near-storm environment

Methodology (cont.)

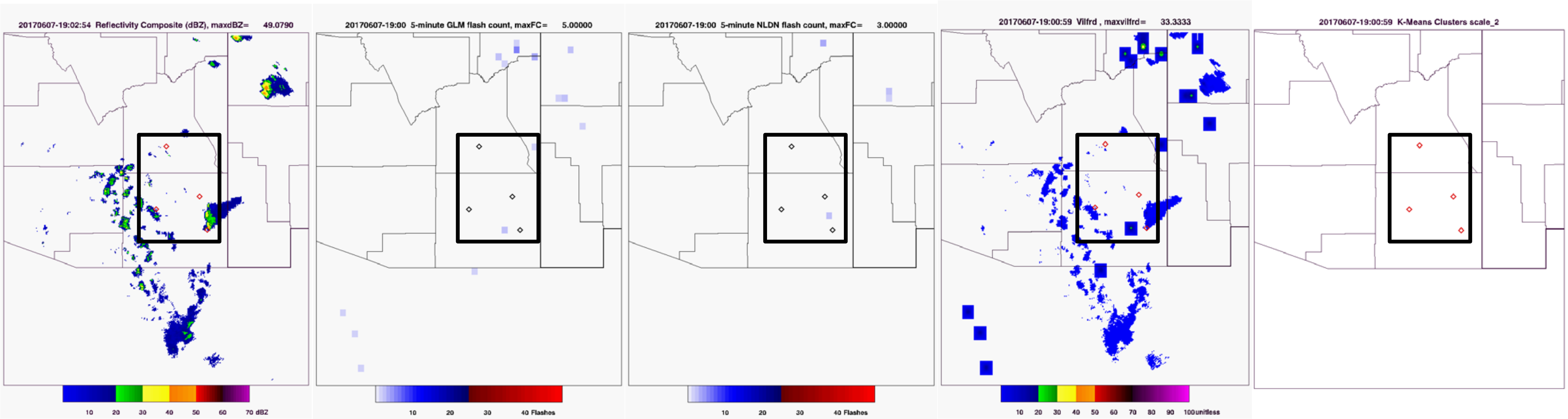
- Tracked features within the 4° by 4° box will also be time-restricted, with only data within +/- 2 hours of the closest tracked feature being included in the final dataset
- Tracked features will be created utilizing the Warning Decision Support System – Integrated Information (WDSSII)
- Scale 2 (65 km^2) will be used instead of scale 5 used in Schultz et al. 2016 to better capture weaker rather than severe storm modes
- For all storms, including non-tracked days, the same limiting parameters will be incorporated (15 km box around fire point), to extract the maximum radar parameters, including the exact radar gate of the closest matched NLDN flash
  - Parameters like graupel mass and max precipitation rate will be calculated this way to help characterize the microphysical properties of the LIW

Interpreting Case Days



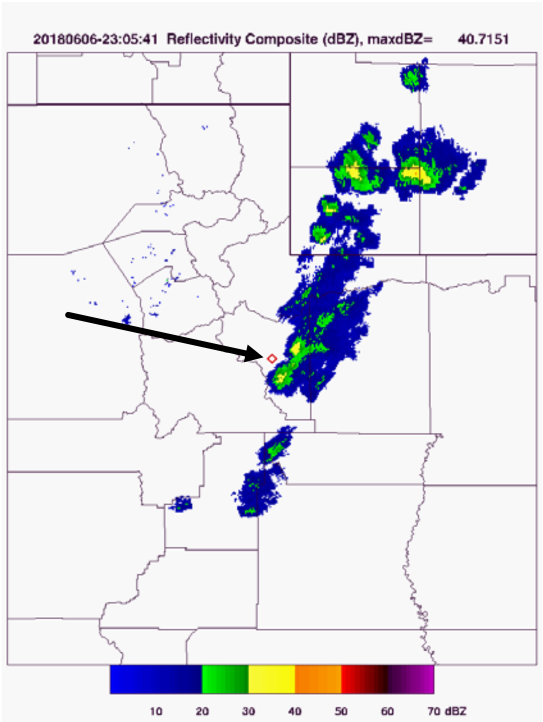
25 May, 2018 LIW in northern Minnesota. From left to right, plots displayed are showing composite reflectivity, 5-minute GLM flash counts, 5-minute NLDN flash counts, Vilfrd, and KMEANS clusters at scale 2. The red and black polygons indicate the fire start origin. Notice fire start point was on the periphery of the core of the storm which passed over.

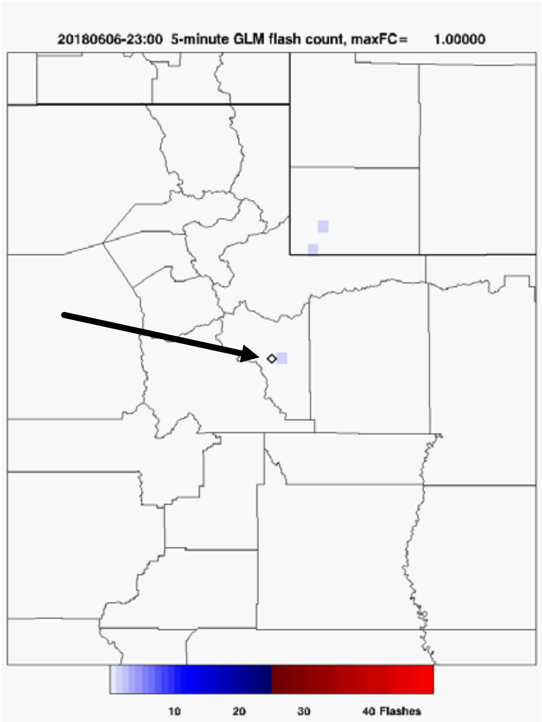
Interpreting Case Days (Cont.)

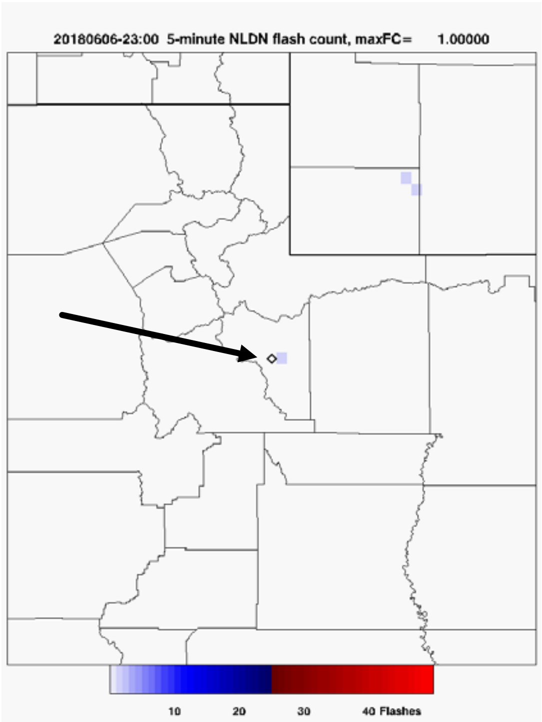


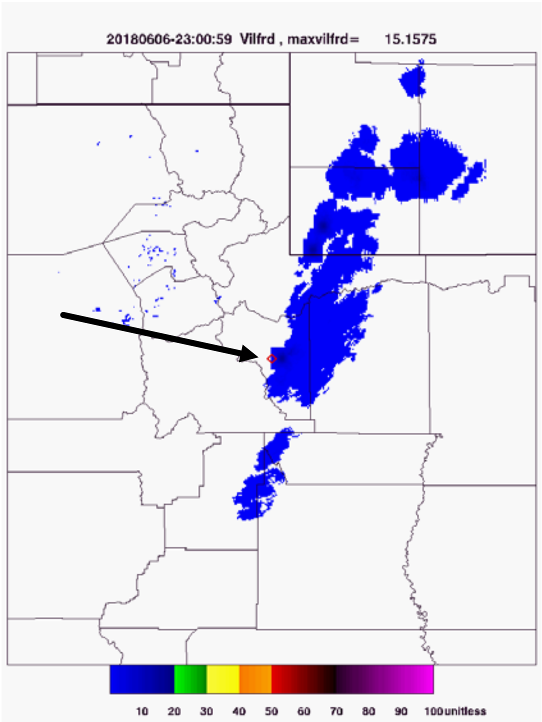
7 June, 2017 LIWs in central and southern Arizona. From left to right, plots displayed are showing composite reflectivity, 5-minute GLM flash counts, 5-minute NLDN flash counts, Vilfrd, and KMEANS clusters at scale 2. The red and black polygons indicate the different fire starts that occurred over the same day. Notice that the vilfrd tracks some of the storms that pass over or near the polygons, but not all. Such LIWs is very typical with the Southwest Monsoon.

Challenges With Tracking







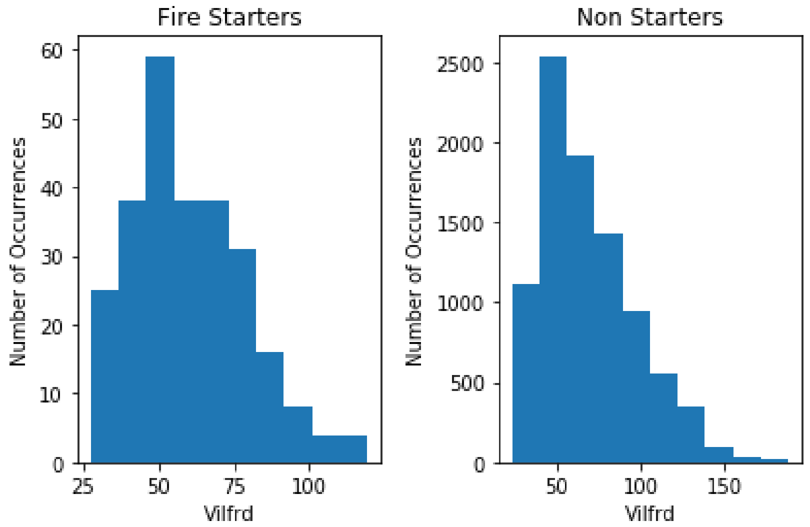


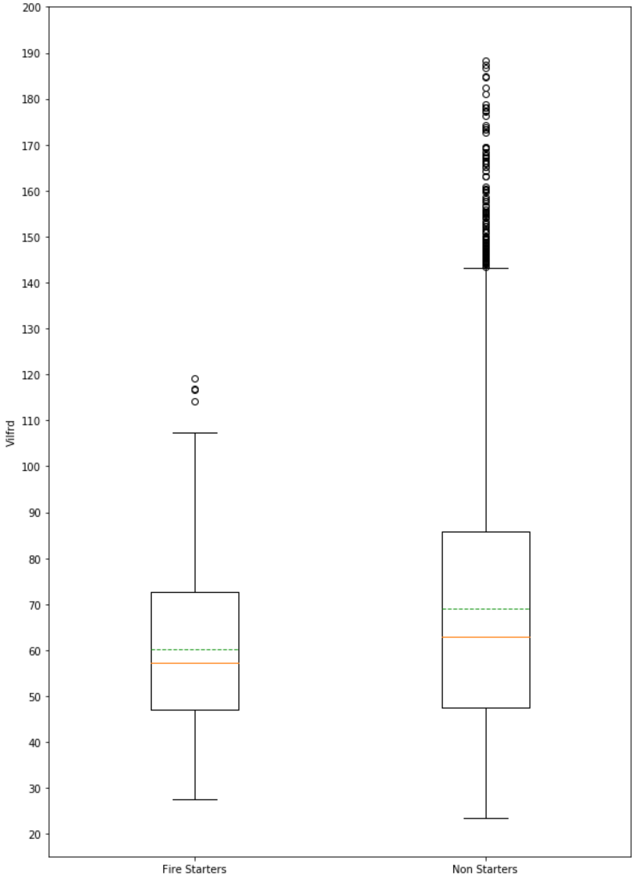
6 June, 2018 LIW in northern Utah, just southeast of Salt Lake City. From left to right, plots displayed are showing composite reflectivity, 5-minute GLM flash counts, 5-minute NLDN flash counts, and Vilfrd. The red and black polygons indicate the fire start origin. Notice the low values of vilfrd (<20) which results in there being no tracked features within 15 km of the fire start and none from 23-24 UTC.

Initial Results

- After developing LIW storm database, combine scale 2 product fields to compute bulk statistics
  - Only include LIW days where a tracked feature is within 15 km box
  - Will have to adapt a different methodology of extracting product fields from LIW storms where vilfrd is too low to be tracked

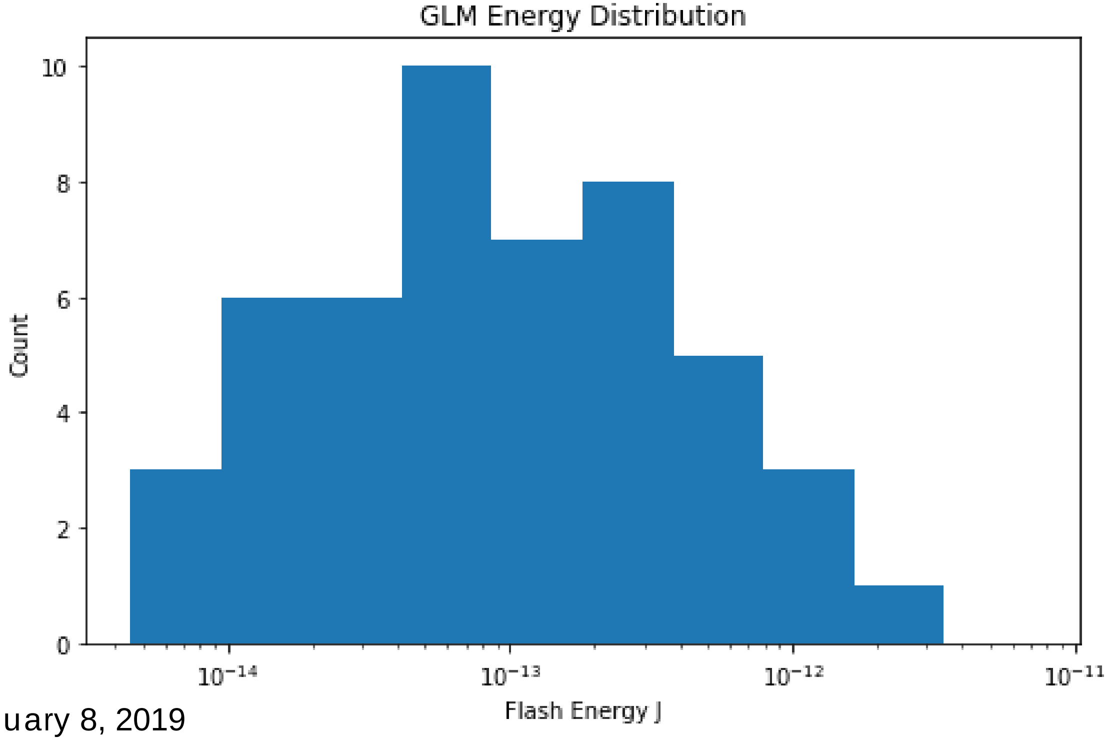
- From the ~51 case days that fit the above criteria, appears that LIW storms are slightly weaker overall than non-LIW storms based on vilfrd values – in line with initial thinking, but more fields need to be looked at

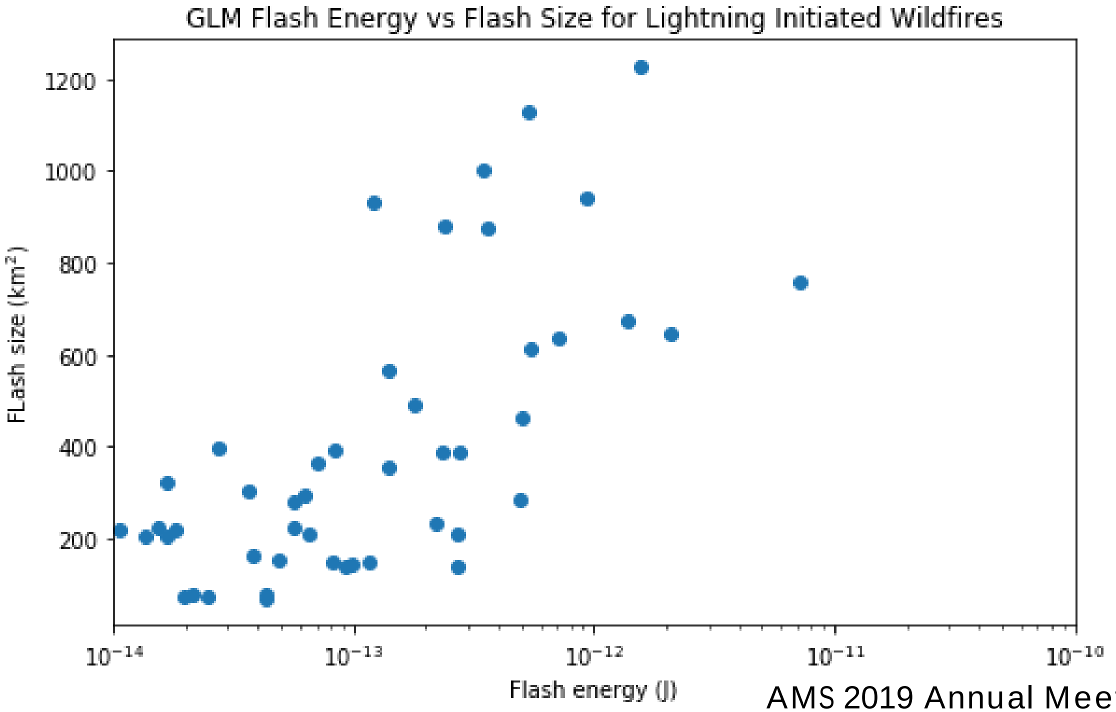




Initial Results (cont)

- For all cases, matched GLM flashes with the closest NLDN flash to the fire start lat/lon
  - Shows typical range of higher flash energy = higher flash area, with a higher concentration favoring generally smaller flashes and energies





Moving Forward

- Continue to address LIW storms where vilfrd is too low – e.g., LIW that are produced by low reflectivity and GLM lightning density
- Begin to track, in time and space, tracked storms created from the vilfrd product by combining features that jump from frame to frame
- Incorporate HID fuzzy logic algorithm for closest fire point to visualize and characterize the structure of the LIW
- For non-tracked cases, create a 15km box around the fire point to extract relevant radar and lightning data for each time
- Implement continuing current (Fairman) or cloud flash fraction (Ringhausen)to understand the evolution of these parameters in fire starting and non-fire starting storms

THANK YOU!

Any Questions?